

28 Rec'd PCT/PTO 20 SEP 1999

Amend

1-2

## Specification

Title of the invention

Semiconductor device and its manufacturing method

5

Technical field

This invention relates to a semiconductor device and its manufacturing method, especially to a reliable technique applying for the resin mold package that seals a semiconductor chip mounted on the die pad of a lead frame.

10

Background technique of the invention

A surface mounted type resin mold package of QFP(QUAD FLAT PACKAGE), etc. becomes a problem that is important to prevent the package crack that occurred in the solder reflow process at the time of a surface mounting of the package.

15

After molding a resin by the transfer mold method, some extent of moisture in the atmosphere has penetrated into the package because the resin that constitutes a package has absorbency. Therefore, heat at the time of a temperature cycle test after package completion, moisture in the resin is suddenly vaporized and expanded by heat at the time of soldering a package to the printed circuit board, and a package crack is caused.

20

As for a package crack that happened like this, it is known that it is especially easy to generate it in the vicinity of the interface between the back of a die pad on which a semiconductor chip is mounted and a resin surrounding it.

5 This is because the adhesion strength of the metal that constitutes a lead frame and a resin is relatively weak, and especially because the die pad is the widest area in the lead frame sealed to the package, a resin breaks away locally from the back of the die pad by the reason why the heat stress that  
10 occurs at the time of a resin sealing process is large and moisture has accumulated in that portion.

The Japanese patent Laid-open No. Toku-Kai-Syou 63-204753 official gazette and the Japanese patent Laid-open No. Toku-Kai-Hei 6-216303 official gazette are proposing the  
15 lead frame structure that restrains an occurrence of a package crack, that is, they are proposing the lead frame structure which has the die pad whose outward appearance is smaller than that of the semiconductor chip mounted on it. According to this lead frame structure, an interface of a die  
20 pad and a resin becomes small, and the quantity of accumulated moisture also becomes small in the interface of them. And the occurrence of a package crack in the back vicinity of a die pad is restrained because a part of the back of a silicon wafer with good adhesion with a resin as compared  
25 with a lead frame comes to touch a resin and makes a direct

interface.

On the other hand, as for the side of the main surface (element formation surface) of a chip mounted on a die pad, the surface passivation film (final passivation film) formed to the top layer part of a chip contacts with the resin that constitute a package. This final passivation film is made of inorganic system insulation materials such as the silicon oxide film or the silicon nitride film that formed by the method of a CVD (CHEMICAL VAPOR DEPOSITION), and the adhesion strength with the resin that constitutes a package is larger than that of a lead frame (metal) and a resin.

In case of the resin mold package that used the above lead frame structure which the outward appearance of a die pad is smaller than that of a chip mounted on it, the package crack in the interface vicinity of the back of a die pad and the resin is restrained, but the adhesion strength of the surface of a chip and a resin does not change.

Therefore, in case a package has a lot of moisture-absorption quantities, a package crack occurs on the side of the surface of a chip because an adhesion strength of the side of the surface of a chip relatively declined comparing to the side of the back of a die pad. And the serious defective as like as a breaking of wires was caused by these problems which has been clarified by the inventors.

The purpose of this invention is providing the technique

that can improve reflow crack resistance of a resin package.

The foregoing and other purposes of this invention, and the new feature of this invention will be described with reference to the accompanying drawings.

5

#### Disclosure of the invention

The outline of the invention that is disclosed in this application is explained as follows.

10 The semiconductor device of this invention is the package that seals a semiconductor chip mounted on the die pad of a lead frame by a resin. And the outward appearance of the above die pad is smaller than that of a semiconductor chip mounted on it. By doing so, the occurrence of a package crack in the vicinity of the back of the above die pad is restrained, and by forming a layer of organic material with good  
15 adhesion with the resin that constitutes a package on the surface passivation film (final passivation film) that covers the top layer of conductive wirings of the above semiconductor chip, the occurrence of a package crack in the  
20 main face vicinity of the above semiconductor chip is restrained.

Besides, a gist of the invention stated in this application is itemized and is explained as follows.

(1) The semiconductor device of this invention is composed of  
25 the package that seals the die pad of a lead frame and a

semiconductor chip mounted on it by resin, and coating the main surface of the above semiconductor chip with an layer of organic material, and the outward appearance of the above die pad was made smaller than the outward appearance of the above semiconductor chip.

(2) As for the semiconductor device of this invention, the layer of organic material of the foregoing (1) is composed of a polyimide resin.

(3) As for the semiconductor device of this invention, the layer of organic material of the foregoing (1) is composed of a photosensitive polyimide resin.

(4) As for the semiconductor device of this invention, the final passivation film that comprises the insulation materials of an inorganic system in the upper part of the top layer of conductive wirings formed on the main surface of the semiconductor chip of the foregoing (1) is formed, and the above layer of organic material is formed over the above final passivation film.

(5) As for the semiconductor device of this invention, a bonding pad is formed by holing the layer of organic material of the foregoing (4) and the above final passivation film, and this bonding pad and a lead of the above lead frame are electrically connected through a wire.

(6) As for the semiconductor device of this invention, the final passivation film of the foregoing (4) is composed of one

of silicon oxide film, silicon nitride film or those lamination films.

(7) As for the semiconductor device of this invention, the lead frame of the foregoing (1) is composed of the Fe-Ni alloy or  
5 Cu.

(8) The method of manufacturing the semiconductor device of this invention includes the following steps.

(a) a step of forming the final passivation film that comprises the insulation materials of an inorganic system in  
10 the upper part of the top layer of conductive wirings after forming the top layer of conductive wirings on the main surface of a semiconductor wafer, and then an layer of organic material is formed over the above final passivation film.

(b) a step of exposing a surface of a bonding pad by selectively etching the above layer of organic material of the upper part of the top layer of conductive wirings and the above final passivation film, said etching being performed by using a photo resist film formed on the above layer of organic  
15 material as a mask.

(c) a step of heating hotly the above layer of organic material after removing the above photo resist film by using a resist removal liquid.

(d) a step of obtaining a semiconductor chip by dicing the  
25 above semiconductor wafer.

(e) a step of mounting a semiconductor chip on the die pad by preparing a lead frame with the die pad with an outward appearance that is smaller than the outward appearance of the above semiconductor chip.

5 (f) a step of sealing the above semiconductor chip and the above die pad by a resin.

(9) As for the method of manufacturing the semiconductor device of this invention, the resist removal liquid of a resist of the foregoing (8) includes the solvent of a phenol system  
10 as the main component.

(10) As for the method of manufacturing the semiconductor device of this invention, after above step of (c) and before above step of (d), further including a step of thinning the thickness of the above semiconductor wafer by grinding of the  
15 back in the condition that the main surface of the above semiconductor wafer is covered with the second photo resist film and a protect tape, and further a step of heating hotly the above layer of organic material after removing the above protect tape and the second photo resist film by using a resist  
20 removal liquid.

(11) The method of manufacturing the semiconductor device of this invention includes the following processes.

(a) a step of forming the final passivation film that comprises the insulation materials of an inorganic system  
25 in the upper part of the above top layer of conductive wirings





embodiment of this invention.

Fig. 2 is the cross-sectional view of TQFP that is one embodiment of this invention.

Fig. 3 is the cross-sectional view of a semiconductor chip  
5 sealed to TQFP that is one embodiment of this invention.

Fig. 4 is the main part cross-sectional view of the semiconductor wafer that shows a method of manufacturing TQFP that is one embodiment of this invention.

Fig. 5 is the main part cross-sectional view of the  
10 semiconductor wafer that shows a method of manufacturing TQFP that is one embodiment of this invention.

Fig. 6 is the main part cross-sectional view of the semiconductor wafer that shows a method of manufacturing TQFP that is one embodiment of this invention.

Fig. 7 is the main part cross-sectional view of the  
15 semiconductor wafer that shows a method of manufacturing TQFP that is one embodiment of this invention.

Fig. 8 is the explanation figure that shows the back grinding process of a semiconductor wafer.

Fig. 9 is the explanation figure that shows dicing process of  
20 a semiconductor wafer.

Fig. 10 is the main part plan view of the lead frame that is used for manufacturing of TQFP that is one embodiment of this invention.

Fig. 11 is the explanation figure that shows the process that  
25

mounts a semiconductor chip on a die pad.

Fig. 12 is the explanation figure that shows the process that mounts a semiconductor chip on a die pad.

Fig. 13 is the explanation figure that shows the process that  
5 mounts a semiconductor chip on a die pad.

Fig. 14 is the flow diagram that shows the manufacturing process of TQFP that is one embodiment of this invention.

Fig. 15 is the flow diagram that shows the manufacturing process of TQFP that is the other embodiment of this  
10 invention.

Fig. 16 is the flow diagram that shows the manufacturing process of TQFP that is the other embodiment of this invention.

Fig. 17 is the flow diagram that shows the manufacturing  
15 process of TQFP that is the other embodiment of this invention.

Best mode to perform the invention

As follows, the examples of the invention are described with  
20 reference to the accompanying drawings.

And, the thing that has the same function in all figures to explain the embodiment of the invention puts the same code and omits the repeated explanation.

Fig. 1 is the perspective view of TQFP(THIN QUAD FLAT  
25 PACKAGE) of which one embodiment of this invention.



As it is shown in Fig. 3, an layer of organic material 8 that comprises polyimide resins is formed on surface passivation film (final passivation film) 7 that covers the top layer of conductive wirings 6 of LSI for the side of the main surface 5 (element formation face) of semiconductor chip 2, and this layer of organic material 8 contacts with epoxy system resin which constitutes the package body 1.

The top layer of conductive wirings 6 of LSI comprises for example, the Al alloys, and final passivation film 7 on them 10 comprises inorganic system insulation materials such as the silicon oxide film or the silicon nitride film that formed by the CVD method.

One end parts of wires 4 to which semiconductor chip 2 and inner leads part 3A are connected are connected to the 15 bonding pads BP which are formed by holing the final passivation film 7 that covers the top layer of conductive wirings 6 and the layer of organic material 8 on them.

According to TQFP of this embodiment that the outward appearance of die pad 5 is smaller than that of semiconductor 20 chip 2 on it, the area of a part where the resin that constitutes the package body 1 and die pad 5 touch and make an interface becomes small, and part of the back of semiconductor chip 2 of which adhesion strength with a resin is better than that of die pad 5 comes to touch a resin and 25 makes a direct interface. Therefore, the occurrence of a

package crack in the back vicinity of die pad 5 is restrained.

Further, according to TQFP of this embodiment that formed layer of organic material 8 that comprises polyimide resins that are the insulation materials of the same organic system as the epoxy system resin that constitutes the package body 1 on surface passivation film (final passivation film) 7 that covers the top layer of conductive wirings 6 of LSI, the occurrence of a package crack in the main surface vicinity of semiconductor chip 2 is restrained because the layer of organic material 8 with a high affinity (with good adhesion) with a resin as compared with final passivation film 7 that is an inorganic system insulation material comes to touch a resin and makes a direct interface.

That is, according to TQFP of this embodiment, good adhesion with a resin which organizes the package body 1 is improved at the both side of the back of die pad 5 and of the main surface of semiconductor chip 2. Therefore, TQFP that reflow crack resistance improved can be realized.

Then, a method of manufacturing TQFP of this embodiment composed like above is explained by using Fig. 4 - Fig. 13 and the process flow figure of Fig. 14.

Fig. 4 is the cross-sectional view that shows the main part (about one chip) of semiconductor wafer 2A that deposits final passivation film 7 on the upper part of the top layer of conductive

wirings 6 for example are formed by the method of patterning Al alloy film deposited on semiconductor wafer 2A by sputtering method. And, final passivation film 7 for example is formed by depositing a silicon oxide film or a silicon nitride film on semiconductor wafer 2A by the CVD method.

Then, as it is shown in Fig. 5, after forming layer of organic material 8 by baking polyimide resin applied by spin method to the upper part of final passivation film 7 at around 180 degree in centigrade temperature, a photo resist film 10 in which a bonding pad formation area was holed to the upper part of layer of organic material 8 is formed as it is shown in Fig. 6.

And bonding pad BP is formed by making holes into layer of organic material 8 and final passivation film 7 by dry etching that made this photo resist film 10 a mask and exposing the top layer of conductive wirings 6.

Then, as it is shown in Fig. 7, photo resist film 10 left on the layer of organic material 8 is removed by using a resist removal liquid. This resist removal liquid is composed of the organic solvents that contain the solvent of for example, phenol system as the main component.

In the removal process of photo resist film 10 that uses the above resist removal liquid, metamorphosis is occurred to the surface of layer of organic material 8 that is composed of polyimide resins that are the insulation materials of the

same organic system as photo resist film 10 by the bleaching to the resist removal liquid, and the adhesion strength (the bonding power) with the resin that constitutes the package body 1 declines. Then, in this embodiment, the good adhesion  
5 (the bonding power) with a resin is recovered by heating the layer of organic material 8 for 4 minutes or more at 350 degrees in centigrade high temperature for example, after removing photo resist film 10. Therefore, the bonding power between the resins constituting the package body 1 and the  
10 polyimide resins constituting the layer of organic material 8 is nearly equal to the adhesion strength (the bonding power) between the semiconductor chip 2 and the resins in the back side thereof.

Thus, according to the present embodiment, by making the  
15 outward appearance of the die pad 5 smaller than that of the semiconductor chip 2, the adhesion strength between the resins and the layer of organic material 8 becomes strong in the front side of the semiconductor chip 2 whose the bonding power has relatively declined in comparison to the resins,  
20 so that both the occurrence of a package crack in the main surface of the semiconductor chip 2 and that of a package crack in the back vicinity of the die pad 5 can be restrained.

Then, the back of semiconductor wafer 2A is ground and the thickness is thinned to 0.4mm in order to seal semiconductor  
25 chip 2 to the TQFP package of which a thickness is 1mm. The

back grinding of semiconductor wafer 2A is done by fixing semiconductor wafer 2A that attached surface protect tape 11 to the main surface side on stage 12 and by grinding the back in diamond wheel 13 that at high speed turns as it is shown in for example, Fig. 8.

Then, surface protect tape 11 attached to the main surface of semiconductor wafer 2A is peeled off and cleaning process to remove foreign materials such as an adherent agent is done, and then, as it is shown in Fig. 9, the semiconductor chip 2 is gained by attaching adherent sheet 14 to the side of the back of semiconductor wafer 2A and separating it into chips by using dicing blade 15.

Then, given semiconductor chip 2 is mounted on a lead frame. As it is shown in Fig. 10, circular die pad 5 that mounts semiconductor chip 2 on the central part of lead frame LF is



supported by suspension leads 16 of 4 pieces. As described above, a remarkable point is that the size of this die pad 5 is smaller than the size of semiconductor chip 2 that is mounted on it.

5 it is arranged to the periphery of above die pad 5 so that the die pad 5 is surrounded by a plurality of leads 3, and it is formed to the halfway part of each leads 3 so that dam bar 17 that served as support of leads 3 and prevention of overflow of a resin at the time of molding connects leads 3 each other.

10 As for leads 3, the inside part of this dam bar 17 composes inner leads part 3A, and outer leads part 3B is composed of the outside part. And, plating of Ag/Ni is done on the tip (bonding area) of inner leads part 3A. External frame 18 and inside frame 19 are formed to most outward part of lead frame

15 LF, and guide hole 20 that becomes a guide at the time of the positioning to the molded die assembly of lead frame LF is formed to part of external frame 18. And, while actual lead frame LF becomes matrix structure on which 5 ~ 6 semiconductor chips 2 can be mounted, the figure is shown

20 only one chip area (unit frame).

Above die pad 5, suspension leads 16, leads 3, dam bar 17, external frame 18 and inside frame 19 that constitute lead frame LF are formed by manufacture of press working or etching of the hoop material of thickness of sheet 0.15mm that

25 comprises 42 alloys and Cu, etc.. And, in case above each part

of lead frame LF is formed by press working, burr (BURR) occurs on the side of the back of a cutting place. A semiconductor chip 2 cannot be bonded when a burr forms in the periphery of die pad 5 because this lead frame LF is  
5 composed of the die pad 5 which has the area smaller than the area of semiconductor chip 2 mounted on that.

Therefore, a burr is made to form in the other side of a chip mounting surface by turning a chip mounting surface to an upper part when pressing die pad 5 and punching it from the  
10 upper part to downward. On the other hand, as for a wire, when there is a burr in the under side, it is hard to bond the tip of inner lead part 3A at the time of wire bonding, and the bonding inferior sometimes arises. Therefore, when pressing inner lead part 3A, a bonding surface is turned to upside  
15 down and is punched from the upper part to downward, and a burr is made to the wire bonding surface side.

And, down set manufacture is done on lead frame LF after the above press working (etching manufacture). Down set manufacture is the work that makes the height of die pad 5  
20 looked at from the level direction lower than the height of lead 3 by bending the halfway part of suspension leads 16 to the lower part by using a press type (no illustration). By this down set manufacture, when installing lead frame LF on which semiconductor chip 2 is mounted in a molded die  
25 assembly and molding a package, occurrence of mold inferior

as a void etc. can be prevented because the thickness of a resin becomes almost equal on the side of the over surface of semiconductor chip 2 and the side on the underneath of die pad 5.

5 As it is shown in Fig. 11 and Fig. 12, adhesive 9 is applied by using dispenser 21 on die pad 5 of lead frame LF in order to mount semiconductor chip 2 on above lead frame LF. Adhesive 9 is composed of the epoxy system resins of thermal hardening mixed with for example, the Ag powder. It is fine  
10 by only applying adhesive 9 to one point of the surface of die pad 5 as for lead frame LF, because the area of die pad 5 is small. Therefore, adhesive 9 can be applied in short time, and an application quantity also finishes in the small quantity.

Then, as it is shown in Fig. 13, lead frame LF is heated to  
15 200~250 degrees in centigrade and adhesive 9 is hardened after positioning semiconductor chip 2 on die pad 5 of lead frame LF by using collet 22.

After that, semiconductor chip 2, die pad 5, inner leads part 3A and wires 4 are sealed to the package body 1 by using a  
20 molded die assembly (no illustration) after connecting bonding pads BP of semiconductor chip 2 and inner leads part 3A of leads 3 with wires 4 by using wire bonding equipment (no illustration), and finally the molding to the gull-wing form of outer lead part 3B completes TQFP that is shown in  
25 above figure 1 and Fig. 2 after cutting and excluding dam bar

17, external frame 18, inside frame 19, etc. that crop out in the outside of the package body 1 in the press.

Table 1 of the next page is showing a result that reflow crack resistance was compared in QFP that seals semiconductor chip 2 that formed layer of organic material 8 on final passivation film 7 by a resin and QFP that seals semiconductor chip 2 that does not form layer of organic material 8 a resin. And, the layer of organic material 8 did high-temperature heating processing and close adhesion with a resin was recovered after removing photo resist film 10 used as an etching mask when forming bonding pads BP in the resist removal liquid.

Table 1 (moisture-absorption condition :85 °C /85% RH  
package thickness :2mm )

Moisture-Absorption time	Presence or absence of an layer of organic material	Chip size	Chip surface exfoliation	Crack
24 hours	P (high-temperature heating)	6.48×6.66	0/45	0/45
48 hours	P (high-temperature heating)	6.48×6.66	0/45	0/45
24 hours	Absence	6.38×8.38	45/45	2/45
48 hours	Absence	6.38×8.38	40/40	1/40

As it is clear from the above table, when layer of organic

material 8 was formed out on final passivation film 7, there were no exfoliation and package crack of the chip surface side, but when layer of organic material 8 was not formed, an exfoliation of the chip surface side was generated and a package crack occurred in all QFP.

This invention was concretely explained above on the basis of an embodiment but, needless to say, this invention is not limited to the above embodiment and it is possible to change it in the range that does not deviate from a gist of the invention.

In the above embodiment, a bonding pad was formed by the hole which was formed to an layer of organic material and a final passivation film by the etching that made a photo resist film a mask after forming the layer of organic material that composed of polyimide resins in the upper part of a final passivation film. And also an layer of organic material can be formed by using a photosensitive polyimide resin. In this case, as it is shown in Fig. 15, after forming hole opening to the upper part of a bonding pad formation area by exposing and developing a photosensitive polyimide resin, the bonding pad is formed by using the hole which was formed to the final passivation film by the etching that made this photosensitive polyimide resin a mask.

In this case, adhesion strength with the resin that constitutes the package body declines because the surface is

exposed to developer in the development process of a photosensitive polyimide resin and is further exposed to an etching liquid when a surface passivation film is holed by wet etching. Therefore, the adhesion strength with a resin is  
5 recovered by heating the photosensitive polyimide resin for 4 minutes or more at 350 degrees in centigrade high temperature for example after forming a bonding pad.

And also, in the process that grinds the back of a semiconductor wafer, a surface protect tape can be attached  
10 on that after applying a photo resist film to the main face in order to protect the main surface of a wafer, and then the back grinding can be done. In this case, as it is shown in Fig. 16, because it is necessary to remove the photo resist film of the lower layer by using a resist removal liquid after the back  
15 grinding of a wafer and peeling off a protect tape, the surface of the layer of organic material that composed of polyimide resins is exposed in the resist removal liquid and metamorphosis is occurred, and adhesion with the resin that constitutes the package body declines. Then, after removing  
20 this photo resist film, adhesion with a resin is recovered by heating a polyimide resin again. In this case, as it is shown in Fig. 17, a photo resist film and a surface protect tape are laminated to the part without high-temperature heating of a polyimide resin after removing a photo resist film used to  
25 form a bonding pad by using a resist removal liquid, and the

back of a wafer is ground, and the photo resist film of the lower layer is removed by using a resist removal liquid after peeling off a protect tape, then a process can be shortened by high-temperature heating of a polyimide resin after that.

5 The layer of organic material that covers the surface of a semiconductor chip is not limited to a polyimide resin, and in case it is a thing with good adhesion with the inorganic insulation layer that constitutes a final passivation film and the resin that constitute the package body, any organic  
10 insulation material can be used.

In case it is the thing that can secure the lowest application area of a chip and the adhesion intensity of an adhesive, the die pad shape of a lead frame is not limited circularly, and the shape is optional. And, the reflow crack resistance can be  
15 improved further by forming a penetrating hole to part of a die pad and enlarging the adhesion area of a chip and a resin.

A package is not limited to QFP, and it can be applied to any package of a surface mounted type that seals a semiconductor chip mounted on a die pad by a resin.

20

Possibility of the industrial use

According to the package structure of this invention, it can be widely applied to a package of a face mounted type that seals a semiconductor chip by a resin because reflow crack  
25 resistance of a resin package can be improved.